Heat generation analysis and anode temperature measurement during the formation of nanoporous aluminium oxide

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ABSTRACT

The fabrication of ordered nano-structured materials through anodic alumina oxide (AAO) template has become an intense research area for understanding the unusual phenomena observed in these materials. The periodicity of the nanostructure relies on the pore morphology of the template, which depends on various factors. Among them, localized Joule heating due to high anodizing current at the pore base was found to alter growth morphology. The influence of temperature on the electrochemical process of anodization is generally evaluated by considering the set electrolyte temperature, while little importance is given to the localized evolved electrode temperature.

In the present work, porous alumina thin films were fabricated using a two-step anodization process. Oxalic acid, 0.3 M, was used as electrolyte and the bath temperature was maintained at 10˚C. FESEM images of the fabricated AAO template are shown in Fig.1. Anodizing voltage was varied from 30-60 V, in the form of ON and OFF cycles as well as in a continuous step of 5 V. A novel approach was made for the measurement of in-situ anode temperature during anodization, where a patterned Pt thin film RTD sensor was sputtered directly on the surface of alumina. The use of this thin film sensor has the advantage of faster response over the conventional RTD due to lower mass. The Pt thin film RTD sensor was calibrated with respect to a Pt 100 sensor for accurate measurements. Anode temperature variations are shown in Fig. 2 when the voltage is applied in ON and OFF cycles of 150 s. The effect of various parameters which contribute to the rise in anode temperature has also been presented. Experiments and theoretical calculations suggest that Joule heating is the major cause of heat generation during the process of anodization.

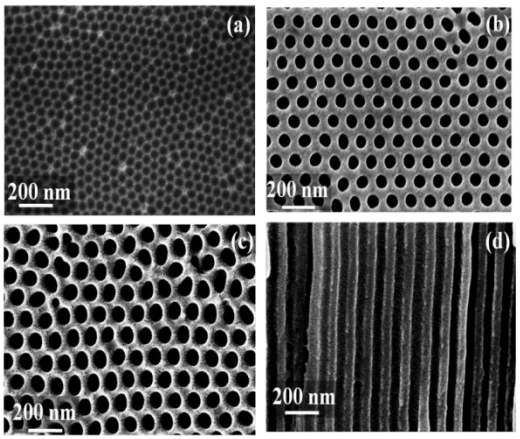

Fig. 1: FESEM images of AAO template: (a) Top view after first anodization (b) top view after second anodization (c) bottom view and (d) cross-section of pores.

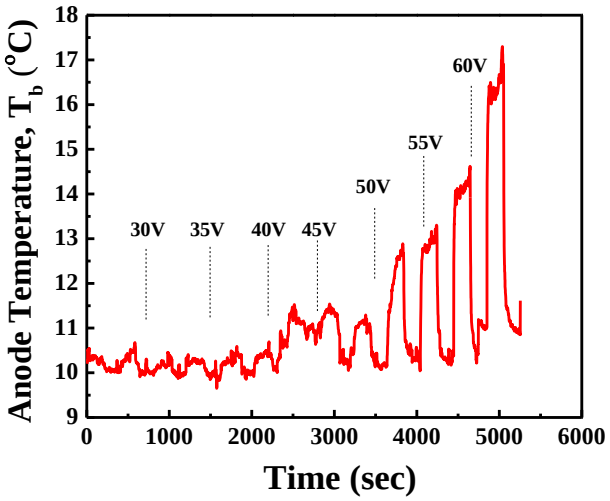

Fig. 2: Variation of anode temperature, T_b with time when voltage is applied in ON and OFF cycles of 150 s